Measurement of the Parity-Violating Gamma Asymmetry in the Capture of Polarized Cold Neutrons by Para-Hydrogen

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The weak interaction between nucleons is mediated through the exchange of $W^{\pm}$ and Z^0 bosons between quarks. The range of the weak force is short when compared to the nucleon-nucleon separation in the nucleus and the weak nucleon-nucleon interaction may be represented by a meson exchange potential. In particular, the parity violating nucleon-nucleon observables can be described in terms of the weak meson-nucleon-nucleon coupling constants: H_π^1, H_ρ^0, H_ρ^1, H_ρ^2, $H_\rho'^1$, H_ω^0, and H_ω^1, which corresponds to the exchange of π, ρ, and ω mesons. An important parity violating observable is the gamma ray asymmetry, A_γ, with respect to the neutron spin in capture of cold polarized neutrons on para-hydrogen: $\vec{n} + p \rightarrow d + \gamma$. The asymmetry, A_γ, is directly related to the weak meson-nucleon-nucleon couplings by:

$$A_\gamma = -0.045H_\pi^1 + 0.001H_\rho^1 - 0.001H_\omega^1 - 0.002H_\rho'^1$$

where the coefficients are well known. Note that the asymmetry is dominated by H_π^1 and a measurement of A_γ is essentially a measurement of H_π^1. The best theoretical values for the weak meson-nucleon-nucleon coupling constants predict the value of the asymmetry of the order: $A_\gamma \sim 5\times10^{-8}$‡. Previous measurements of H_π^1 in ^{18}F and other systems have resulted in very different values†§ but a precise determination of H_π^1 from the asymmetry A_γ will resolve this issue.

The goal of the NPDG experiment* is to measure the asymmetry, A_γ, to better than 0.5×10^{-8} at the Los Alamos Neutron Science Center (LANSCE). Neutrons from the LANSCE spallation target are thermalized with a liquid hydrogen moderator and guided to the experimental apparatus shown in Fig. 1. The experimental apparatus consists of a ^{3}He neutron spin filter, a RF neutron spin flipper, a liquid hydrogen target (catalyzed by paramagnetic material), and a CsI detector array that is used to detect the 2.2 MeV gamma ray from neutron capture. The magnetic guide fields, RF spin flipper, ^{3}He neutron spin filter, and data acquisition systems were brought to LANSCE and tested during an engineering run in November. Analysis of this data showed that these components performed on the whole as expected. The few small modifications that are needed will be done during the second engineering run in February/March of 1999. This second run will also provide diagnostic tests on the CsI detectors and beam monitoring as well as testing the system by performing a 10% measurement of the parity violation in ^{35}Cl. The US Department of Energy at the end of 1998 favorably reviewed the experiment proposal.

Footnotes and References

*The NPDG Collaboration institutions are: Los Alamos National Laboratory, Petersburg Nuclear Physics Institute, Indiana University, University of Michigan, University of California and the Lawrence Berkeley National Laboratory, National Institute of Standards and Technology, University of New Hampshire, Kyoto University, KEK National Laboratory, and the Joint Institute for Nuclear Research.

†E. Adelberger and W. Haxton, Ann. Rev. Nucl. Part. Sci., **35**, 501 (1985).

‡B. Despanques, *et al*., Ann. Phys. **124**, 449 (1980).

§C. Wood, *et al*., Science **275**, 1759 (1997).

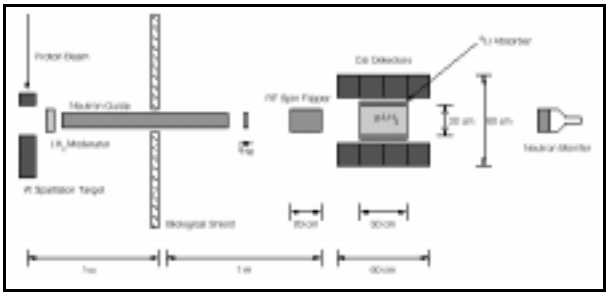

Fig. 1. Conceptual design of the proposed NPDG experiment.